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Detection of Non-Resolved Elastic Strain in Quartz from Brooklyn Granulites

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Introduction: Granulitic charnockite is a member of the granite family produced under extreme metamorphic conditions. Recent Tunnel Boring Machine (TBM) logs produced during mining of the Brooklyn Water Tunnel #3, Brooklyn, New York, show that these granulites are associated with excessive cutter wear and appear to be among the most stress-resistant rocks ever mined by TBM methods [1]. It is important to determine the extent to which excessive hardness may relate to the work-hardening of quartz at high metamorphic grade. Quartz is a major mineral in these granulites and exhibits undulatory extinction and kink banding often associated with the proposed work-hardening condition, but rarely compared quantitatively to engineering strength properties, such as uniaxial compressive strength.

Methods and Materials: Internal strain can be resolved by traditional x-ray diffraction line-broadening analysis. Brooklyn Water Tunnel granulite ('popping rock'), a low temperature granite and a quartz standard were prepared following standard x-ray powder diffraction protocols.

Results: Full width at half maximum (FWHM) was normalized to peak height for rock mixtures containing approximately 40% quartz. The difference in normalized FWHM relative to quartz standard resolves line broadening. 'Popping' quartz, e.g. quartz recovered from rock walls that exploded into the tunnel cavity due to non-resolved stress, is clearly subject to line broadening as shown by the strong positive deviation in Figure 1. A second quartz from a non-deformed, low temperature granite shows a lesser positive deviation relative to the control.

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References:

[1] S.C. Chesman, and J.C. Steiner, "Microstructural study of tonalitic gneisses exposed by TBM-mining of New York City's third water tunnel", in International Journal of Rock Mechanics and Mining Sciences Special Issue, ISRM International Symposium 36 U.S. Rock Mechanics Symposium, eds. J. A. Hudson and K. Kim, v. 34, No. 52, 850-863, 1997.

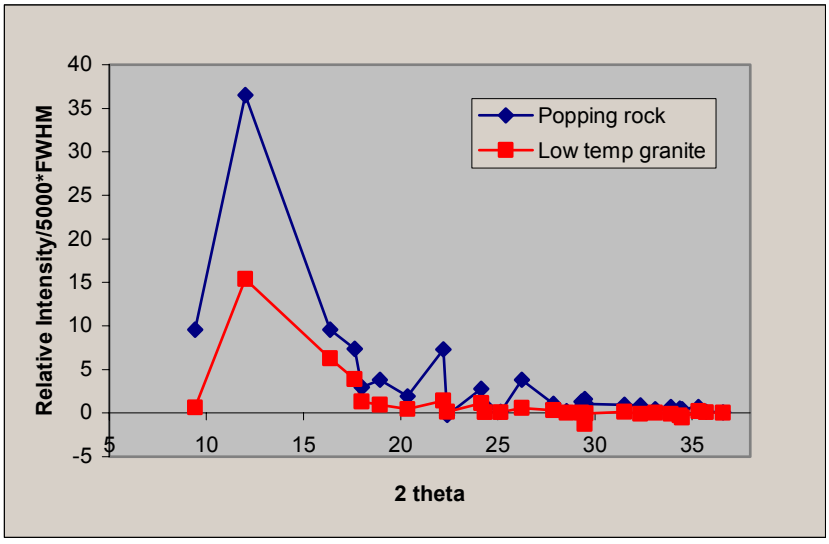

Figure 1. Comparison of line broadening in two quartz samples possessing different degrees of non-resolved elastic strain. The 'popping rock' clearly shows a greater degree of line broadening than the low temperature granite.